INTERPRETATIONAL AMBIGUITIES IN CONJUNCTION PROBLEMS

By

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Tversky and Kahneman have used conjunction problems to
support their general contention that people utilize the
representativeness heuristic in place of appropriate
statistical principles when making judgments under
uncertainty. In such problems, subjects are offered a
choice between a compound event and one of the constituent
events. In violation of sound extensional reasoning as
represented by the conjunction rule, which states that the
conjunction of two events can never be more probable than
either of its components, subjects most often choose the
compound event as the more probable. An alternative
explanation for such choices in terms of linguistic
misinterpretation was examined in the present study. This
misinterpretation may occur at two levels. At Level I, the
subject does not even recognize the relevance of an
extensional interpretation. At Level II, the subject may
consider an extensional interpretation, but inappropriately
represent the sample space of the constituent event.

Ambiguities exist in the problems at both levels and turn, in part, on common conversational conventions of language.

In four experiments, involving 485 subjects, four possible interpretational facilitators were manipulated. A betting scenario and an instructional wording variable were utilized as Level I manipulations, and survey information and a response option clarifying phrase as Level II manipulations. Neither Level I factor led to any significant effects. At Level II, the clarifying phrase proved robust across experiments, but there was a significant interaction between this factor and survey information. Each of these factors was effective only when the other was absent. Responses to an Euler circle interpretational task in Experiment 4 indicated that the clarifying phrase was effective in creating the correct interpretation of the response option sample space. The results of these four experiments indicate a significant interpretational component to performance on conjunction problems and suggest further experiments to contrast the heuristics and misinterpretation explanations of such performance.

INTRODUCTION

The conjunction problems developed by Tversky and
Kahneman (1982, 1983) are a set of word problems, which, in
each case, requires subjects to correctly apply the
conjunction rule in order to arrive at what the authors of
the problems argue is the "correct" answer. The conjunction
rule is a fundamental rule of probability that states that
the probability of two events occurring conjointly cannot be
higher than the probability of occurrence of either event
independently. For instance, the probability of rolling
both a six and a one with a pair of dice cannot exceed the
independent probabilities of rolling either a six alone or a
one alone, and in fact, the joint probability in this
particular case (1/36) is much less than either of the
independent probabilities (which in each case is 1/6). The
conjunction rule can also be considered to apply in cases of
category membership, where one category subsumes the other.
For example, the probability of someone having both blond
hair and blue eyes cannot exceed the probability of that
person having blue eyes only. This is because members of
the set "having blue eyes" contains those of all hair
colors, including blond. The two kinds of applications of
the conjunction rule seem to me to be fundamentally

different, although Tversky and Kahneman treat them as equivalent. All of Tversky and Kahneman's conjunction problems involve reasoning about categories that consist of the latter kind of conjunction. In this regard, they are more appropriately called category membership problems and the term "conjunction problems" may be a misnomer.

In any case, the majority of subjects presented with conjunction problems do not choose the designated "correct" answer, and therefore their responses are discrepant with the responses that would result from the application of the conjunction rule (Tversky & Kahneman, 1982, 1983).

Kahneman and Tversky's examination of conjunction problems is part of a larger program which indicates that the decisions which subjects render on a variety of problems do not conform to those that result from the application of a number of probability principles (e.g., Kahneman, Slovic, & Tversky, 1982). Other than the conjunction rule, these principles include Bayes's Theorem, regression to the mean, and the law of large numbers.

Kahneman and Tversky have argued (see Kahneman & Tversky, 1972, 1973; Tversky & Kahneman, 1974, 1983) that these discrepancies are the result of people assessing uncertainty in a way that is fundamentally different from that indicated by probability theory. They give an account of what this other way is that involves subjects reasoning by means of a small handful of favored "heuristics," or

judgmental rules-of-thumb. Reliance on these heuristics leads to the systematic neglect of variables indicated as relevant by probability theory and opens the door for debates about whether or not man is a "rational" being.

This dissertation will examine the use of conjunction problems in Tversky and Kahneman's arguments that human reasoning is inadequate in its use of certain aspects of problem information and proceeds irrespectively of fundamental statistical principles. Evidence and arguments will be presented that the difficulties that subjects experience with conjunction problems are not the result of inadequate understanding of the conjunction rule or an inability to apply it but result instead from misinterpretations of the problem task. These misinterpretations are in turn caused in part by the overall problem structure, which invites a particular interpretation that is at odds with that which the developers of the problem see as the correct one, and in part by ambiguity in the interpretation of the response options.

The first part of the dissertation will provide an overview of the history and philosophy necessary for a full understanding of the place of conjunction problems in contemporary research. The second part of the dissertation will provide a review of the literature that has accumulated around conjunction problems. This review will culminate in an overview of the experiments performed as part of the

dissertation to investigate ambiguities in one of the most well known of the conjunction problems. The third part will present four experiments that indicate a misinterpretational component in subjects' responses to conjunction problems. The fourth part will provide a general discussion that incorporates the experimental results and calls into question the continued use of conjunction problems as examples of human judgmental incompetency.

HISTORICAL OVERVIEW

In this section I identify several analogies that have
played a role in psychological thinking, then focus on two
metaphors that are shaping contemporary reasoning research,
and that bear directly on the research on conjunction
problems.

The Use of Metaphor in Psychology

It is a difficult task to characterize the mind, and
philosophers and scientists throughout history have often
resorted to analogy. Unable to say exactly what the mind
is, they have settled for saying what the mind is like.

Two of the most important classical metaphors for
memory come from Plato. In the Theaetetus (translated by
Waterfield, 1987), Plato has Socrates asking his listeners
to imagine the mind as containing a block of wax.
Perceptions and ideas make impressions on the wax block, as
would a signet-ring, and as long as the impression remains,
we can remember that which caused the impression. As the
impressions in the wax become less distinct, so do our
memories for those events. The wax blocks can vary in size,
consistency, and purity, which accounts for the differences
in people's ability to learn and remember.

Later, Socrates considers the mind as possessing an aviary. The aviary of an infant is empty, but as pieces of knowledge are acquired, it is like capturing birds and confining them in the aviary. The birds in the aviary are like accessible memories, but in order to actually remember something, the bird must be once again gotten hold of.

William James (1890) drew an analogy between memory and a theater back-drop, upon which objects are painted to give an illusion of continuous perspective. He wrote that "we paint the remote past, as it were, upon a canvas in our memory, and yet often imagine that we have direct vision of its depths" (p. 643).

Analogy has been used for mental processes other than memory. In his second lecture at Clark University in 1909, Freud (1910/1965) asked his audience to imagine an ill-mannered and disrupting person being removed to the outside of the lecture hall by several strong men, who then continues his disturbance by shouting and banging on the door. The continued effort of the strong men are required in order to prevent his return, or a mediator must act as peacemaker to directly confront the unruly person and talk with him until he can be readmitted on better behavior. By this analogy, Freud attempted to create a picture of the conscious, the unconscious, and repression, as well as of the psychoanalytic process.

Roediger (1980) writes how both these early psychologists also utilized the metaphor of the house. For James, the house was a memory metaphor, with objects to be searched for in its rooms, and sometimes misplaced. For Freud, the house, with its reception room and antechamber, served as another metaphor for consciousness and unconsciousness.

More recently, there have been analogies of mental processes to a purse (Miller, 1956) and to an attentional "pool" (Kahneman, 1973).

Roediger (1980) discusses how short-term memory has been described, among other things, as a work bench, long-term memory as a library, and how metaphors used in psychology often reflect the latest technology: the mind as gramophone, telephone switchboard, tape recorder, Paris metro subway map, and hologram. Neither did Freud escape the influence of scientific advances contemporary to his time. The mind for him adhered to the laws of thermodynamics in the same way that the newly invented steam engine adhered to the laws of thermodynamics.

A recent powerful metaphor in psychology has been the computer metaphor, which born at the end of World War II and allied with information theory, initiated the birth of cognitive psychology. This metaphor suggested the use of flow charts to characterize cognitive processes (Broadbent, 1958), and engendered several decades of fruitful research.

The impact of the digital computer metaphor is well documented (e.g., Gardner, 1985; Lachman, Lachman, & Butterfield, 1979). However, like all metaphors, the digital computer one may be short-lived in its influence (Roediger, 1980).

The flow-chart model of human mental activity was based on the operations of the serial-digital computer. There is a new approach to computer modelling, however, that has suggested to some a current metaphor shift within the cognitive psychology field (e.g., Palmer, 1987; Schneider, 1987). These new models are called parallel distributed processing models, neural network, or connectionist models, and are loosely based on the characteristics of the neuron (McClelland & Rumelhart, 1986; Rumelhart & McClelland, 1986). It may be too early to tell to what degree this new approach will supersede the digital computer metaphor but Palmer (1987) has said, "the current 'program metaphor of the mind' will be replaced with something that might be called, only somewhat facetiously, the 'brain metaphor of the mind'" (p. 925).

There are other metaphors of mind that are currently influential in shaping psychological thought. Two metaphors in particular are interesting because of their influence on research in the area of thinking. These two metaphors are thinking as perception, and thinking as statistics, and there are historical precedents for both.

Thinking as Perception

Wilhelm Wundt is considered the founder of scientific psychology. In 1875, he established in Leipzig, Germany, one of the first two experimental laboratories in experimental psychology. The other was established in the same year by William James at Harvard (Watson, 1978).

Wundt divided psychology into two broad areas. One of these was experimental psychology which used introspection as its method, and attempted to analyze conscious experience into its elements by means of conducting experiments on individuals. Some of the research topics investigated experimentally at the Leipzig lab included aspects of sensation and perception such as peripheral vision, color contrast, negative after-images, color blindness, visual size, optical illusions, and time-sense, or the perception of the passage of time. Other topics were reaction time, attention, feeling, imagery, span of apprehension (how much can be taken in at a single glance), and verbal associations (Schultz, 1981). Many of these latter topics form chapter titles in contemporary textbooks of cognition (e.g., Matlin, 1989).

Wundt's second area of psychology, which he called Volkerpsychologie, or "cultural psychology", was the study of the higher mental processes. The higher mental processes of thinking, problem solving, and memory could not be studied experimentally because they resulted from or were

profoundly influenced by the collective psychology of groups, and were not simply the experiences of the individual. The higher mental processes were to be studied observationally by means of their products, which are language, myth, and custom (Leahey, 1980).

With this division of psychology into an experimental psychology and an observational psychology, with perception in one area and thinking in the other, it was impossible for a comparison to be drawn between perception and thinking. However, developments occurred that prepared the way for the emergence of the perception metaphor in thinking.

Oswald Kulpe was a student of Wundt's who disagreed that introspection could not be used to experimentally study the higher mental processes. As early as 1879 Ebbinghaus had begun to show that the experimental study of the higher process of memory was possible, and by 1885 his results were published and available. By 1896, Kulpe had established his own laboratory at Wurzburg, Germany, where introspective investigations of the higher process of thinking were regularly being carried out. While Wundt's introspective methods called for a more immediate, descriptive account of a simple perceptual experience, Kulpe's methods often involved more of a retrospective account, interrupted by questions from the experimenter, following performance on a complex problem-solving type task. In addition to differences in the use of the introspective method, the

Wurzburg psychologists diverged from the Wundtian program by stressing the existence of unconscious elements of thinking, imageless thought, and unconscious "determining tendencies" or dispositional sets that were established by task instructions and guided conscious thought activity. The at-times-bitter debate between the Leipzig and Wurzburg schools called into question the validity of introspection as a experimental tool and prepared the way for the acceptance of John B. Watson's behaviorism. Though the Wurzburg school itself essentially dissolved following the departure of Kulpe in 1909, the ideas of the Wurzburg psychologists influenced and evolved into the school of Gestalt psychology, which offered a more sustained and systematic approach to the study of thinking (Leahey, 1980).

The Gestalt psychologists expounded a holistic approach to perception and explained perception as the act of restructuring elements within the visual field until some stable configuration was obtained. The restructurings were guided by unconscious principles of perception such as closure, similarity, and figure-ground perception. Thinking was also seen holistically, with a similarly successful restructuring of problem elements necessary in order for problem solving to occur. When the visual elements of a scene were suddenly restructured into an appropriate grouping, the subject "saw" the scene. Likewise, when the problem elements of some problem were suddenly restructured

into an appropriate grouping, the subject "saw" the solution. In thinking, this sudden successful restructuring was called "insight".

The approach of the Gestalt psychologists to thinking is important because they stressed not only the idea of a restructuring of problem elements into potential alternative interpretations but also the importance of problem presentation, task instructions, linguistic phrasings, and the examples used as factors which guided and constrained problem restructurings. Additionally, these factors were thought to operate in an unconscious fashion.

The Gestalt position on thinking as perception probably reached its highest expression in the work of Karl Duncker (1945). In contrast to many contemporary approaches to thinking, which are driven by the statistical metaphor, and see task instructions as something neutral which merely serve to elicit the thought process, Duncker saw task instructions as a major factor in facilitating and inhibiting particular restructurings--one might say interpretations--of problem elements. Consider, for example, Duncker's tumor problem, which requires subjects to solve the problem of destroying a stomach tumor with radiation without damaging intervening tissue. When the instructions contained the active phrase of: How could one prevent the rays from injuring the healthy tissue?, 43% of subjects dealt with varying the intensity of the radiation.

When the instructions contained the passive phrase of: How could one protect the healthy tissue from being injured by the rays?, only 14% of the subjects dealt with radiation intensity.

Unfortunately, Duncker's experimental approach and the Gestalt program of the experimental study of thinking were to be prematurely curtailed. One reason is the appearance of Nazism in Germany. Many of the Gestalt psychologists or their wives were Jewish, with the result that some went into hiding, some died in the concentration camps, and many fled the country. Duncker came to the U.S. He found the country immersed in the behaviorist doctrines of John B. Watson and little interested in a psychology of the mind. In 1940, dismayed by the turn of events in Germany and the lack of academic acceptance of his ideas in the U.S., he committed suicide (Gigerenzer and Murray, 1987).

Thinking as Statistics

From its beginnings, statistics have been used as a metaphor for thinking. Laplace called the new science of probability "only common sense reduced to calculus."

The early 1900's saw the rapid development of statistics into an inferential tool. Pearson developed the x^2 in 1900, and Fisher set forth asymmetrical hypothesis testing and the analysis of variance (ANOVA) in his books, Statistical Methods for Research Workers and Design of

<u>Experiments</u> in 1925 and 1935, respectively. Neyman and Pearson published their first joint paper on symmetrical hypothesis testing in 1928. Between 1940 and 1955, these newly developed statistical tools became indispensable to psychologists. Not long after, the first statistical metaphors began appearing in psychological theorizing (Gigerenzer and Murray, 1987).

As an example, consider Neyman and Pearson's symmetrical hypothesis testing approach. This approach was important because it allowed for the subjective and mathematical aspects of hypothesis testing to be separated. The experimenter set a criterion, based on a subjective assessment of the risks and payoffs involved in making errors or being correct, and was able to determine acceptable levels of type I error and power. The sampling distribution was determined according to the mathematical laws of probability theory.

This model first appeared as a psychological theory in the form of the theory of signal detection (Tanner & Swets, 1954). It was used again by Wickelgren and Norman (1966) as a model of recognition memory.

Another example of a statistical method being used as a psychological theory is that of Harold Kelley's (1973) causal attribution theory, which is analogous to a Fisherian three-way ANOVA.

From the very beginnings of the translation of statistical methods into psychological theories, there has been a basic confusion between a descriptive approach and a prescriptive approach. Attempts to descriptively characterize human thinking as analogous to statistical methods often became confused with direct comparisons of human thinking to statistical methods. It was often assumed that statistical methods were standards by which rational human thought should be judged. This prescriptive approach reached its highest expression in the work of Kahneman and Tversky (e.g., Kahneman, Slovic, & Tversky, 1982).

These researchers and others have painted a bleak picture of human rationality, often characterizing their subjects as judgmentally incompetent. Subjects are postulated to use a small number of simple context and content independent heuristics, avoiding the utilization of information that would be important from a statistical standpoint. The tasks and instructions themselves are seen as unimportant, only as vehicles that conform to a statistical interpretation and should therefore elicit a statistically influenced response.

In recent years, however, there has been a new approach to research in human reasoning that is very similar to the Gestalt tradition in the study of thinking. It signifies a return to the perceptual metaphor in thinking research.

The Rebirth of the Gestalt Tradition

The overtly pejorative tone of Kahneman and Tversky's work engendered several protesting responses. A position taken by Cohen (1981) is to deny the normative status of particular statistical principles for particular problems. Cohen attempts to salvage human rationality by arguing that subjects are appropriately using statistical principles in their reasoning, but different ones than those chosen by the experimenter. For instance, Cohen argues that subjects are using Baconian probabilities in certain instances rather than Bayesian ones in order to account for the discrepancies between subjects' responses and a Bayesian outcome. Cohen is thus seen as remaining within the confines of the statistical metaphor.

A different position is to question the very basis of Kahneman and Tversky's explanation and propose alternative explanations based on a perceptual metaphor. Explanations brought forth from the perceptual metaphor focus on a subject's interpretation of a problem and the elements of the problem which contribute to that interpretation. Under the Kahneman and Tversky position, one must accept the human inference process as imperfect. Under the perceptual metaphor, the possibility exists that poor performance is driven by a misrepresentation of the problem or a misinterpretation of the evidence provided, or of problem elements, in ways other than that which the experimenter

intended. Frisch (1988) has pointed out that just because people's judgments systematically deviate from probability theory, it doesn't necessarily mean that they are using a common heuristic, as Kahneman and Tversky have assumed. It could mean that they are misinterpreting something about the problem in a common way based on cues that invite those particular mistakes. Likewise, that formal training in statistics does not improve the tendency to answer certain problems correctly (Tversky & Kahneman, 1983), could mean that the heuristics used are exceedingly robust, as Kahneman and Tversky have concluded, or that particular misinterpretations are so strongly cued that subjects never become aware of the relevance of statistical principles in the first place.

The last several years have seen a reemergence of the perceptual metaphor in theoretical accounts of reasoning, and an emphasis on the subject's interpretation of problems. Recent theoretical works on reasoning (e.g., Evans, 1989; Margolis, 1987) have stressed the importance of investigating those factors and processes that guide a subject's interpretation of a problem, instead of merely focusing on the comparison of a subject's response to the answer a relevant statistical method would yield. For instance, Margolis (1987) has postulated a two-stage theory of reasoning that includes an initial stage of pattern recognition and a subsequent rationalization stage. Evans

(1989) has likewise theorized an initial automatic selection stage, followed by manipulation of the selected aspects of the problem. This second stage is also guided in an often unconscious manner. Both authors stress the importance of the content of reasoning problems and subjects' familiarity with it, as well as the influence that context and language play in resolving ambiguities of interpretation and directing attention. This emphasis on the unconscious processes that constrain inference is congruent with the Wurzburg idea of "determining tendencies" and the Gestalt approach in general, as discussed by Gigerenzer and Murray (1987) and Gardner (1985).

Likewise, empirical work has gained momentum in investigating the effects of content, context, and linguistics on the reasoning process. This has taken place in work on logical reasoning (e.g., Cheng & Holyoak, 1985; Cosmides, 1990; Griggs & Cox, 1982) as well as statistical reasoning (e.g., Nisbett, Krantz, Jepson, & Kunda, 1983).

In the next section, I examine both theoretical and empirical work on Kahneman and Tversky's conjunction problems that falls within the general bounds of being guided by the perceptual metaphor.

REVIEW OF THE LITERATURE

In this section of the dissertation I begin by giving a fuller account of the heuristics approach of Kahneman and Tversky. Their studies with the Linda problem--the most well-known of the conjunction problems--are closely examined. Several alternative explanations to performance on the Linda problem are then considered. The alternative explanations have suggested several experimental manipulations and these manipulations and their results are discussed. The section ends with an overview of my own experimental manipulations.

Brief Introduction to Conjunction Problems and the Heuristics and Biases Approach

Conjunction problems were first introduced in "Judgments of and by Representativeness" (Tversky & Kahneman, 1982) as examples of subjects' utilization of the representativeness heuristic. According to Kahneman and Tversky (1973), when people are faced with tasks of assessing probabilities and making predictions under conditions of uncertainty, they rely on a limited number of simple, but abstract and content-independent heuristic strategies that supplant the more appropriate but complex

operations of statistical and probability theory. These
heuristics consist of mere assessments of similarity, in the
case of the representativeness heuristic, and of ease of
recall or scenario generation, in the case of the
availability heuristic. Reliance on these heuristics leads
people to ignore prior probabilities (base rates), neglect
considerations of predictive accuracy and evidence
reliability, be insensitive to sample size differences, fail
to consider regression to the mean, misperceive the
fundamental notions of chance and be susceptible to illusory
correlations and unwarranted confidences (Tversky &
Kahneman, 1974).

The Linda problem, among other conjunction problems,
was constructed to point out that even one of the most basic
and fundamental rules of probability, the conjunction rule,
would be ignored and violated in situations where the
representativeness heuristic would indicate a contrary
judgment. The conjunction rule states that a compound or
joint event cannot have a higher probability of occurrence
than either of its constituent events. The conjunction rule
can be stated in the terms $P(A) \geq P(A+B)$. In the Linda
problem, subjects violate the conjunction rule by giving a
joint event (that includes a very representative constituent
event) a higher probability of occurrence than a constituent
event that is very unrepresentative, i.e., by considering
A+B more probable than A. (It has already been noted in the

Introduction that Kahneman and Tversky's conjunction problems involve joint and independent events that are all actually category membership decisions.)

Tversky and Kahneman's (1983) approach to the conjunction fallacy is somewhat different from their earlier approaches to the base-rate fallacy, the fallacy of the law of small numbers, etc., in that in their earlier writings (Tversky & Kahneman, 1974; Kahneman & Tversky, 1972, 1973) the authors not only stated that subjects digressed from the principles of probability theory in favor of use of the representativeness heuristic, but also that people evidently did not develop intuitions anywhere near analogous to the law of large numbers, the principle of regression to the mean, or Bayes's Theorem. Thus, the layperson was not a naive, but adequate statistician at all, as was indicated by Peterson and Beach (1967), but an incompetent one, possessing not even rudiments of normative probability theory. In fact, expert practitioners such as physicians and mathematical psychologists were shown to be as prone to biases engendered by the representativeness heuristic as the layperson (Tversky & Kahneman, 1983).

Since their earlier work, however, Tversky and Kahneman (1982) have backed away from their extreme hypothesis that some judgments of likelihood are arrived at solely by the representativeness heuristic, and representativeness is now seen as only one of any number of possible procedures useful

for retrieving, interpreting and evaluating information. It
is still seen as a highly favored one, however. They are
now willing to admit that subjects are capable of utilizing
sample size information, reliability information, and base
rates, but that such utilization is dependent on problem-
specific variables, design characteristics, the subject's
statistical sophistication, and demand characteristics or
other suggestive clues. In this, it is clear that their
position has been influenced not only by a growing volume of
evidence unsupportive of the heuristics approach but also by
the characteristics of the perceptual metaphor.

Accordingly, Kahneman and Tversky (1982) now
characterize errors into two basic types. Whereas
previously all errors were discussed as if errors of
comprehension, i.e., errors which resulted from failure to
recognize or understand a statistical rule, now many errors
are seen as errors of application, in which the subject
knows, understands, and accepts a statistical rule as valid
but does not apply it in a case where the experimenter
considers it to be normatively appropriate to do so. Such a
moderation of position significantly weakens the heuristics
and biases approach and focuses attention on the nature,
strength, and degree of abstraction of statistical
principles, the role of intelligence in inducing such
principles from education or experience, whether such
principles remain content bound or are abstracted, and the

variables which aid or hinder the encoding of a problem such that it makes contact with these principles. These considerations are being explored by Nisbett and colleagues (e.g., Holland, Holyoak, Nisbett, & Thagard, 1986; Jepson, Krantz, & Nisbett, 1983; and Nisbett, Krantz, Jepson, & Kunda, 1983).

The conjunction problem experiments (Tversky & Kahneman, 1982, 1983) indicate the influences of this different approach to judgment under uncertainty in that Kahneman and Tversky characterize the conjunction fallacy as more likely an error of application than an error of comprehension, and search for conditions that mitigate the bias, being concerned with such variables as the effects of statistical sophistication and rephrasings of the problem on commission of the error. Kahneman and Tversky are also much more willing to address criticisms of their view and discuss alternative explanations, though in each case, they argue that the outcomes of their manipulations continue to support the interpretation that the representativeness heuristic is the dominant strategy used by subjects.

The Linda problem is an English-language equivalent of four problems tested by Kahneman and Tversky in Israel in 1974 (Tversky & Kahneman, 1982). In these early between-subjects versions of conjunction problems, a brief personality sketch was presented that matched the stereotype of a particular occupation (e.g., cab driver), followed by a

list of five or six target events to be rank ordered. For
half of the subjects, the list contained a simple event of
which the sketch was highly representative (e.g., "is a cab
driver") and of a simple event of which the sketch was
highly unrepresentative (e.g., "is a member of the Labor
party"), plus four other items. For the other half of the
subjects the list contained a joint event made up of these
two constituents (e.g., "is a member of the Labor party and
drives a cab"), and the same four remaining items. Half of
each group then ranked the items according to the
probability of the person described being a member of that
class, while the remaining half ranked the items according
to the degree to which the description was representative of
a person belonging to that class. In both cases, the
compound event was ranked higher than the unrepresentative
constituent, which for the probability ranking group is a
violation of the conjunction rule. In fact, the
representativeness ranking and the probability ranking of
each set of targets were almost identical, a finding which
Tversky and Kahneman interpreted as meaning subjects were
assessing probability by means of representativeness.

Tversky and Kahneman also developed within-subjects
versions of conjunction problems consisting of eight target
statements. The following is the within-subjects version of
the Linda problem as it was originally introduced (Tversky
and Kahneman, 1982):

> Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.
>
> Please rank the following statements by their probability, using 1 for the most probable and 8 for the least probable.
>
> (5.2)   Linda is a teacher in elementary school.
> (3.3)   Linda works in a bookstore and takes Yoga classes.
> (2.1)   Linda is active in the feminist movement. (A)
> (3.1)   Linda is a psychiatric social worker.
> (5.4)   Linda is a member of the League of Women Voters.
> (6.2)   Linda is a bank teller. (B)
> (6.4)   Linda is an insurance salesperson.
> (4.1)   Linda is a bank teller and is active in the feminist movement. (A+B)

The numbers before the target statements are the mean ranks as they were assigned by 173 subjects. Note that the statement "Linda is a bank teller and is active in the feminist movement" is ranked as more probable than the statement "Linda is a bank teller". This conjunction fallacy of ranking a compound target above the less representative simple target was exhibited by 89% of the subjects. Rankings were similar for a second group asked to rank order each statement by its representativeness.

Another version of the Linda problem with only the two targets B and A+B was tested (Tversky & Kahneman, 1982). Each target served as a response option and subjects were instructed to choose the option that was more probable:

> Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of

discrimination and social justice, and also participated in antinuclear demonstrations.

Which of the follow is more probable? (Check one)

a) Linda is a bank teller
b) Linda is a bank teller and is active in the feminist movement.

Tversky and Kahneman had hypothesized that this would make the logical relationship between the targets more transparent. However, the conjunction fallacy was not reduced, with 87% of subjects tested (n=86) selecting the compound target as the more probable of the two options.

This was replicated by another group of subjects (n=147), with 85% of respondents committing the conjunction fallacy (Tversky & Kahneman, 1983).

In all cases, it was argued that probability judgments were being driven by representativeness. Another possible explanation that Tversky and Kahneman did not consider was that "probability" was being interpreted by their subjects, not in the statistical sense of relative frequency, which is the one that the experimenter intended, but in an everyday sense of "plausibility," or "believability." This more parsimoniously explains the identical responses by subjects to the two kinds of instructions to rank by probability and to rank by representativeness: Subjects were simply giving the two statements the same reading! A fuller discussion of the way that the structure of the problem itself contributes to this linguistic ambiguity and the implications for all

manipulations of conjunction problems will be delayed until below, when alternative explanations are considered, but another important point must be made here. In order for the argument that the conjunction rule is the normative model to apply to these problems to succeed, it is necessary to impose a particular framework upon the task: Each target item to be ranked or each response option, depending on the form of the problem, must be seen from the perspective of the probability of membership in a category given a description. Considering the target item or response option as a hypothesis and the description as data, this yields a P(Hypothesis/Data) perspective. This perspective is not the same as one of P(Data/Hypothesis) or the probability of the description being accurate given membership in a particular category. A reversal makes each consideration an independent assessment of representativeness and no longer yields a framework within which the conjunction rule is applicable.

Now, consider that Tversky and Kahneman (1982) stress representativeness as a directional relation between a process and a model or an instance and a model and that it only makes sense to speak of a sample as being representative of a population, an act representative of a person, or an instance representative of a class and not vice versa. This directionality thus leads naturally to an assessment of the representativeness of a sample, act, or

instance given the characteristics of the population, person, or class. When Tversky and Kahneman asked their subjects to rank the items according to "the degree to which X [the described person] is representative of that class" or "the probability that X is a member of that class" (Tversky & Kahneman, 1982, p. 90), they imposed a directionality on the task. Both instructions impose the framework of assessing probability or representativeness of the description given the class of the target item. Again, considering the description as data and the target item as hypothesis, this yields a P(Data/Hypothesis) perspective, the reversal of the P(Hypothesis/Data) perspective necessary for the conjunction rule to be normatively applicable. So we see that as constructed these problems are flawed and specious.

Tversky and Kahneman were perhaps aware of this directionality cue and its invalidation of the conjunction problems presented in 1974, because in the Linda problem (Tversky & Kahneman, 1982) and all subsequent conjunction problems they constructed, such instructions were deleted; subjects were subsequently asked to "rank order the statements by their probability," from most probable to least probable. This makes the misdirection of the problem implicit rather than explicit, but does not correct the basic difficulty.

Several other difficulties in the structure of the Linda problem have been suggested by a number of different authors, each serving as an alternative explanation for the pattern of responses usually seen. These alternative responses to the heuristics approach are now considered.

Survey of Alternative Explanations

There are several alternative explanations as to why the conjunction fallacy occurs. Though some of the explanations can be seen as distinct and separate from each other, others can be seen as being related. Most alternative explanations for the Linda problem do not question the normative status of the conjunction rule or attempt to support some other statistical principle as being more normatively appropriate to the problem, as Cohen (1979, 1980, 1981) has done in the case of the base rate and sample size problems used by Kahneman and Tversky. Instead, most explanations are concerned with subjects' possible misinterpretations of elements of the problem or a misrepresentation of the problem in its entirety. These concerns are congruent with an acceptance of the perceptual metaphor.

One alternative to the use of the representativeness heuristic in explaining the responses to the Linda problem and other conjunction problems has been called the "linguistic confusion" hypothesis (Tversky and Kahneman,

1982; 1983; Wells, 1985). However, since linguistic confusion could refer to any of several aspects of the Linda problem, I will rename this hypothesis the "mutually exclusive or" hypothesis. According to this argument, the meaning of one of the response options is being misinterpreted. The response options could be read within a framework of "which is more probable, this option or this one", with an implied "or" connecting the statements. Within conventional language usage, "or's" are often mutually exclusive (Margolis, 1987). For instance, the phrase "are you having pie or pie a la mode?" implies pie without ice cream versus pie with ice cream as your choice. Therefore, reading the statements in the Linda problem as "Which is more likely, that Linda is a bank teller, or that Linda is a bank teller active in the feminist movement," subjects are prone to read the first choice as "Linda is a bank teller and not active in the feminist movement." This destroys the inclusive relationship of the two response options and turns the latter, most often chosen statement, "Linda is a bank teller and active in the feminist movement", into an arguably appropriate response.

A second postulated linguistic confusion (Paulos, 1988) is that within the context of being asked if Linda is a bank teller, subjects take the statement of Linda as a bank teller and feminist as possible additional information. Instead of reading the "and" as indicative of a conjunction,

subjects read the statement as "Given that Linda is a bank teller, what are the chances of her also being a feminist." Such a reading would also justify attaching a higher probability to this situation than to Linda being strictly a bank teller. Subjects are in effect preferring a conditional probability interpretation to a joint probability one. (Evidence for this will be discussed in the next section, which deals with the empirical results of experimental manipulation.)

Another alternative to representativeness is the "sample-space" hypothesis (Markus & Zajonc, 1984; Morier & Borgida, 1984; Wells, 1985). This explanation assumes that there is some ambiguity to the way that the problem is stated that steers the subject away from forming the proper sample space for dealing with the response options. Normative responding requires the subject to form sample spaces which are at hierarchically different levels, with one category representation subsuming another. Most subjects may spontaneously be attempting to resolve all sample spaces at the same hierarchical level. The relationship between the "sample-space" hypothesis and the "mutually exclusive or" hypothesis is that the linguistically ambiguous structure of response alternatives in the Linda problem invites improper interpretations of sample space (Markus & Zajonc, 1984), so that the direct cause of the conjunction error is in the formation of an

inappropriate sample space, but this is in turn implicitly generated by the misinterpretation of the linguistically ambiguous individual response options (Wells, 1985).

Another explanation is that the overall structure of the problem as well as the practical tendency of the subject leads to an assessment of P(D/H) when the assessment normatively called for is P(H/D), as previously discussed. Given such an interpretation, again we see that responses are normatively appropriate. The misinterpretations of the problem can now be seen to be operating at two different levels. At one level are the various misinterpretations of the target statements that can detract from formation of an appropriate sample space. At a higher level is the ambiguity in the overall structure of the entire problem. I will refer to this ambiguity of the entire problem as Level I ambiguity, and the ambiguities at the level of the target statements (or response options) as Level II ambiguities.

Several alternative explanations are subsumed under Margolis's (1987) discussion of the problem. Margolis (1987) explains the responses on the Linda problem as resulting from an interaction of what he calls "semantic ambiguity" and "scenario ambiguity." Semantic ambiguity is the susceptibility of a word or phrase to multiple meaningful interpretations. Scenario effects constitute the larger context within which the problem is seen and which

guides resolution of semantic ambiguities. Scenario effects themselves can be ambiguous.

According to Margolis, the Linda problem contains both semantic ambiguities and ambiguous--or downright misleading--scenario effects. It is the combination of these effects that leads to the proportion of incorrect responses usually seen. The scenario effects spring from alternative possible contexts. On the one hand, the problem can be seen from a viewpoint of relative frequency assessment, and this is what the authors of the problem intended. (Actually, it is my contention that the authors constructed their task in such a way as to purposefully mislead. Consider: "Our problems, of course, were constructed to elicit conjunction errors, and they do not provide an unbiased estimate of the prevalence of these errors" [Tversky & Kahneman, 1983, p. 311]).

On the other hand, the problem can be seen within the context of the assessment of the believability or plausibility of a situation. Unfortunately, the word "probable" that Tversky and Kahneman chose for their instructions encompasses both meanings, as does its synonym, "likely." Here, the single word "probable" has semantic ambiguity, which is resolved according to the way in which the scenario ambiguity is resolved. This is what Margolis means by the interaction of scenario and semantic ambiguities. I will later discuss how the overall structure of the problem overwhelmingly leads the unalerted reader,

even statistically sophisticated ones, to a "plausibility" reading of "probable."

According to Margolis (1987), subjects' answers make sense if it is taken that they are interpreting the problem within this "believability" framework, if they are also influenced by two other semantic ambiguities. One of these, says Margolis, is that the two statements about Linda are interpreted as implying a mutually exclusive relationship, as has already been discussed. The implied "or" in "Linda is a bank teller or Linda is a bank teller active in the feminist movement," implies an interpretation of "Linda is a bank teller" as "Linda is a bank teller and not active in the feminist movement."

Furthermore, even without these other difficulties in interpretation, the small difference in frequency between the classes of the two target items are negligible in practical terms. With such a description, it is highly unlikely that Linda would be a bank teller, and even less likely that she is also a feminist. But both probabilities are vanishingly small. Such a difference is for all important practical purposes unimportant and is easily lost in the larger contexts and ambiguities that the problem presents. It is, unfortunately, this difference that subjects are being asked to assess.

Margolis's scenario ambiguities I consider to be equivalent to my Level I ambiguities, and his concern with

misinterpretations of mutual exclusivity in the target statements I consider to be Level II ambiguities.

Margolis (1987) is the first author to contend that performance on the Linda problem is the result of the convergence and interaction of multiple ambiguities or misleading influences at different levels, and that debiasing of the Linda problem will require manipulations along each of the three lines he discusses. Previous authors seem to have taken the view that only one approach to debiasing is required, and that only one alternative explanation for the conjunction fallacy should be considered at a time.

It appears, however, that this small problem presents complications beyond, but related to, the three that Margolis discusses, though I am in complete agreement that compounded effects are what make the problem so resistant to facilitative manipulations. The difficulties I would add are those already discussed: (a) that there is a confusion between the conditional probability of the description given the hypothesis of membership in a target class, or $P(D/H)$, and the conditional probability of the hypothesis of membership in a target class given the description, or $P(H/D)$, which is what is supposedly being asked for; (b) that there is confusion between the joint probability of Linda being a bank teller and a feminist, or $P(B\&F)$, which is how the authors mean the phrase to be taken, and the

conditional probability of Linda being a bank teller given
that she is a feminist, or P(B/F), or its converse, p(F/B),
(Paulos, 1988); and, (c) that the normative approach that
Tversky and Kahneman prescribe for this problem makes the
descriptive and class information provided completely
irrelevant to the solution of the problem, in complete
violation of the Gricean conversational cooperativeness
principle (Grice, 1975).

This third problem can be understood more clearly by
briefly considering the field of pragmatics. Pragmatics may
be considered a subarea of linguistics, but for our purposes
it might be defined as the psychology of utterance
interpretation, or of how disambiguation of utterance
meaning is achieved, how reference is assigned, how
implicatures (inferences intended by the speaker) are
arrived at, etc. (Sperber and Wilson, 1981). Much of
pragmatic theory hinges on the social cooperativeness
achieved by two speakers. To the extent that what passes
between experimenter and subject can be conceived of as a
conversational exchange, theories of pragmatics are
relevant.

Perhaps most germane to the Linda problem is Grice's
(1975) Cooperative Principle (CP). Under the CP, speakers
will strive to be relevant and informative. According to
Adler (1984), the very structure of the Linda problem is
uncooperative in the Gricean sense, because there is nothing

about the description of Linda offered or the particular classes to which we are asked to consider she might belong that is differentially relevant to the judgment we are being asked to make. In other words, any description of Linda, and any category or conjunction of categories offered would make absolutely no difference in arriving at the normative response. In normal exchange, however, what people offer each other is differentially relevant. We are led to assume, by every experience we have ever had, that what is being offered about Linda and these categories is somehow relevant to the judgment we are required to make. This is the main reason why subjects misinterpret the problem and why nearly all unalerted subjects will more plausibly read "probable" as "believable," because it is only this interpretation that makes the description of Linda offered differentially relevant.

It is here that a basic difference between the statistical metaphor and the perceptual metaphor becomes more apparent. Kahneman and Tversky say we ought to solve the Linda problem by applying the conjunction rule, ignoring the context and content of the problem. Their explanation of why we don't do this is that we apply a heuristic that makes an abstract assessment of similarity between a description and a category and in so doing also ignore the content and context of the problem. Both their prescription and their explanation are based on an acceptance of the

position that reasoning is driven by formal rules. The perceptual metaphor stresses the actual content of any situation and how a problem solver attempts to wrestle meaning from that situation, stressing that while resolution of ambiguities often appears to be a rule-like behavior, the resolution is always bound to the content and context of the situation.

The tendency is for subjects to interpret the particular content of the Linda problem according to the socially acceptable rules of conversational exchange. It is this overall pragmatic difficulty in the problem that I believe would qualify as a Margolian scenario ambiguity and that I categorize as a Level I ambiguity. While Margolis (1987) recognizes the importance of pragmatics and sees them as contributing to the general class of scenario effects, he does not see the two as being synonymous. However, it is my contention that the "believability" misinterpretation is fostered by the very structure and nature of the problem itself and such an inherent fault may not be correctable without substantially altering the task itself, making it no longer a test between representativeness and other judgmental strategies. There is a strong link between all such problems of representativeness and pragmatics. Where Kahneman and Tversky see the ubiquitous and insidious conjunction fallacy, affecting judges, physicians, journalists, psychologists, etc., and unmitigated even by

prolonged statistical training, I see only the ordinary workings of pragmatics. The pragmatic "pull" of the Linda problem appears to be stronger than that of most of the other conjunction problems that Tversky and Kahneman have constructed, and so we would expect the Linda problem to be the most intransigent when it comes to facilitating manipulations than the other problems, and in fact, this appears to be the case (e.g., Fiedler, 1988; Tversky & Kahneman, 1983). Still, by understanding the conjunction of effects that make the Linda problem so difficult given the pragmatic framework, it should be possible to get significant reductions in "error" by making the appropriate manipulations and to be able to see why those manipulations that have worked do so. Margolis (1987) has suggested various changes in the Linda problem which would directly address the scenario and semantic ambiguities he has pinpointed. A consideration of these proposed manipulations served as the rationale for the design of Experiment 1. However, before discussing any new attempts at facilitation, the results of some previous manipulations will be discussed.

Survey of Manipulations and Their Results

Tversky and Kahneman (1982) originally gave the eight-statement version of the Linda problem to three groups differing in statistical sophistication, and found that more

than 80% of subjects in each group, regardless of statistical sophistication, exhibited the conjunction fallacy. This included a group of graduate students in a decision science program who had taken a number of advanced probability and statistics courses!

Since these experiments, a number of researchers have examined the Linda problem, and several other conjunction problems introduced subsequently by Tversky and Kahneman (1983), all of which are easily replicated in their original form (e.g., Fiedler, 1988; Macdonald & Gilhooly, 1990; Morier & Borgida, 1984; Wolford, Taylor, & Beck, 1990).

Tversky and Kahneman (1983) themselves were among the first authors to further investigate the conjunction fallacy. After moving from the eight-statement version to one with two response options, they considered whether the relationship between the compound target and simple target in the two statement version might be interpreted as that of an implied mutually exclusive "or", so that "Linda is a bank teller" was being read as "Linda is a bank teller and not a feminist". Such an interpretation would of course be appropriately considered less likely than that "Linda is a bank teller and a feminist" and turn the 85% incorrect responses into correct ones. To test for this, Tversky and Kahneman replaced the possibly misinterpreted statement with "Linda is a bank teller whether or not she is active in the feminist movement", which the researchers affirmed to

"emphasize the inclusion of T&F [teller and feminist] in T [teller]" (p. 299). One could argue whether their rephrasing was, in fact, the best way such an inclusion could have been emphasized, or whether it, in fact, clearly resolved the ambiguity for most subjects. But still, even such an attempt lowered the percentage of subjects committing the conjunction fallacy from 85% to 57%! Even with such an improvement, Tversky and Kahneman report that they were still surprised that their subjects could so blatantly violate what was now, to them, perfectly clearly an extensional situation. That conjunction errors still occurred can be explained as being due to the still ambiguous wording of the supposedly clarified statement, and the still present scenario effects in which the differentially relevant description and the word "probable" created a plausibility context.

Moving on to their next modification, Tversky and Kahneman included the following in the task instructions for the two-statement version: "If you could win $10 by betting on an event, which of the following would you choose to bet on?" (p. 300).

Here again, violations of the conjunction rule were driven down by more than 30% to 56%, which Tversky and Kahneman still considered "much too high for comfort" (p. 300). Conjecturing that the betting context drew attention to conditions under which such a bet would pay off, Tversky

and Kahneman moved on to other manipulations. One wonders why Tversky and Kahneman acted as if there could be only one possible alternative explanation for incorrect responding, committing a "fallacy of monocausality" in the process, and did not combine the two manipulations of target statement clarification and betting scenario. Such a combination, of course, is just what Margolis (1987) suggests is necessary to correct the confounding influences in the problem.

Next, Tversky and Kahneman gave the eight-statement version of the Linda problem to social science graduate students with several statistics courses under their belts in a rating scale version, where target items are rated as to likelihood rather than rank ordered. Here, unlike their earlier (Tversky & Kahneman, 1982) results, only 36% of the statistically educated graduate students committed the fallacy. Such a result is much more in keeping with Jepson, Krantz, and Nisbett's (1983) idea that statistical reasoning is a skill like piano-playing, or chess, that can be learned, and not a competence, as Tversky and Kahneman seem to see it, that is uniformly lacking from all subjects. It is possible, however, that facilitation occurred because subjects had to rate each target item individually as to its probability rather than rank order all items. This will be discussed further when considering similar results from another (Morier & Borgida, 1984) study that directly addresses the issue.

In the rest of their 1983 paper, Tversky and Kahneman go on to show how the conjunction fallacy is committed by practicing physicians on problems of a medical nature, is encountered in prediction problems that involve conjunctions as well as problems of gaming probabilities, causal situations, motives and crimes, and forecasts and scenarios.

In a section of the paper on extensional cues, Tversky and Kahneman (1983) admit that although people have an "affinity for nonextensional reasoning, it is nonetheless obvious that people can understand and apply the extension rule" (p. 308). Here, they clearly part company from their earlier positions, when they were wont to say that subjects lacked such statistical rules.

Tversky and Kahneman (1983) report several other manipulations that reduce the conjunction fallacy. What Tversky and Kahneman call "a seemingly inconsequential change" (p. 309) of having subjects assess percentages of people belonging to each of the simple targets separately before assessing the relative frequency of the compound target brought the rate of the conjunction error down to 31%. Estimating how many out of 100 patients fit in each of the categories of the two constituent and a compound target brought down the incidence of error to 11%! I would suggest that there are two influences occurring here, one at Level I and one at Level II. These manipulations work at Level I by making a frequency interpretation unavoidable, and also by

making the P(D/H) versus P(H/D) confusion less likely to occur, since estimating frequencies of a class forces one to assume a P(H/D) perspective. The manipulations work at Level II by indicating the appropriate sample space. This is accomplished by means of explicitly stating the two constituents prior to the compound event and thus making the mutual exclusivity error less likely to occur. Though what Tversky and Kahneman termed nonextensional reasoning prevailed to 11% even in these very transparent problems, this is nonetheless a 74% reduction in error from base rate!

Though Tversky and Kahneman (1983) report these reductions in error, they lack a framework within which to interpret them. They fall back on saying that "[it] appears that extensional considerations are readily brought to mind by seemingly inconsequential cues" (p. 309). They go on to note the contrast between extensional cues being effective in certain of the conjunction problems and the relative inefficacy of extensional cues in the Linda problem. Without asking why it might be so, they conclude that the contrast in effectiveness of cues exists because some conjunction problems are concerned with classes and others with properties and that "although classes and properties are equivalent from a logical standpoint, ... [this equivalence] is apparently not programmed into the lay mind" (p. 309).

The overall mood of the paper is a very condemning one, with nonextensional reasoning made out to be a great danger, human reasoning being a battleground between appropriate statistical and logical rules and "seductive nonextensional intuition" (p. 314).

Subsequent research by others has shown that the conjunction fallacy has proven to be very responsive to a number of task specific variables, to the degree that Tversky and Kahneman's contention that a general inferential judgmental heuristic is being applied seems very unlikely. Locksley and Stangor (1984) found that the conjunction error was reduced somewhat by formal statistical training and knowledge of the conjunction rule, but that performance was more strongly affected by task-specific cues. Locksley and Stangor imputed conjunction problem results to causal reasoning on the part of the subject, which has been shown to occur with great spontaneity and facility (e.g., Michotte, 1963; Schustack, 1988). The authors reasoned that while common events may more often be reasoned about with a multiply sufficient causal schema (i.e., any one of several factors being sufficient), rare events would more likely cue a multiply necessary causal schema (i.e., several factors operating in concert being necessary). They tested this prediction with two problems similar in structure to the original Linda problem. It was stated in one problem that Bob is married, and in the other that John has committed

suicide. Each statement was then followed by a number of
target items, some of which were conjunctions. It was found
that, in fact, in the problem with the rarer outcome of
suicide, 72% of subjects committed the conjunction error, as
compared to 29% for the common outcome problem. This may
have some bearing on the Linda problem, because as Margolis
(1987) states, given her description, Linda is so unlikely
to be a bank teller that either option of bank teller, or
bank teller and feminist, would be an unusual thing.

Using the eight statement version of the Linda problem,
Morier and Borgida (1984) found that when subjects directly
estimated the probability of occurrence of each target
statement, performance was improved compared to performance
when subjects rank ordered the statements. The conjunction
error was reduced by about 15%, from 95% to 80%. The
experimenters had predicted that some small reduction would
result from ties being possible between the compound target
and the two constituent elements. And, in fact, 8 of the 60
subjects in the probability estimation condition assigned
equivalent probabilities to the compound event and
constituent event, which is allowable within the parameters
of the conjunction rule. A second, additional explanation
for the small improvement is that a portion of the
conjunction error is due to the previously mentioned
possibility of confusion between different conditional
probabilities, i.e., between P(event/description) and

P(description/event). Such a confusion is understandable and though still possible under the probability estimation condition, may be somewhat ameliorated.

Including the statement "Linda is a bank teller who is not a feminist" along with the statement "Linda is a bank teller" reduced the bias from baseline by about 18% (Morier and Borgida, 1984). More interestingly, bias was reduced by around 47% by a four-statement version that included the option "Linda is a bank teller or is active in the feminist movement". Such a manipulation was thought to cue more clearly the logical structure of the task. Of course, if one wanted to fully follow up on this course, the approach would be to offer explicit statements about every possible state of class membership of Linda. Such an exhaustive list of alternatives would be as follows:

1. Linda is a bank teller.

2. Linda is a bank teller and not an active feminist.

3. Linda is both a bank teller and an active feminist.

4. Linda is an active feminist.

5. Linda is both an active feminist and a bank teller.

6. Linda is an active feminist and not a bank teller.

7. Linda is neither bank teller nor feminist.

8. Linda is either a bank teller or a feminist.

Because such a list of statements is exhaustive, the problem space should be very clearly cued and very clearly

delimited, and linguistic errors involving mutually exclusive "or's" should be kept to a minimum.

Crandall and Greenfield (1986), found that linguistic training in the explicit and implicit roles of the conjunctive "and" did not improve performance while probability training did. However, the probability training provided by Crandall and Greenfield may have served less to educate subjects in the conjunction rule--which most subjects will already endorse in the abstract form--so much as providing them examples of encoding the situation of the Linda problem in such a way that it makes mappable contact with such abstract rules (see Nisbett et al., 1983, for a discussion of when statistical rules will be cued by a problem). In addition, the linguistic training of the meanings of the conjunctive "and" may not have directly addressed the mutually exclusive "or" problem.

Nahinsky, Ash, and Cohen (1986) allow that biases in probabilistic reasoning result in part from the use of judgmental heuristics, but they also maintain that some errors are due to incorrectly understood concepts of probability as well as difficulties in information processing. They presented subjects with some problems for which a relative frequency interpretation was explicit and found that nonetheless there were errors due to a confusion between joint and conditional probabilities. They suggest the conjunction fallacy may appear as a by-product of this

confusion. Such findings should alert us to the fact that we should be vigilant against over-simplified approaches to the Linda problem. Such a phenomenon as the conjunction error may not be done justice by seeing it simply through a performance/competence distinction framework (Evans, 1988), or an error of comprehension/error of application framework (Kahneman & Tversky, 1982).

Recently, Fiedler (1988) has reported significant reductions of anywhere from 40 to 60% in the amount of conjunction errors across a range of conjunction problems, including the Linda problem, merely by making a single change in the task instructions. This change was from the instruction to rank order a list of eight items according to their probability, as in the original eight-statement version of the Linda problem, to making a frequency assessment of to how many out of 100 people would each of the statements apply, as was suggested originally by Tversky and Kahneman (1983). The author concluded that the conjunction fallacy turns for the most part on the semantic ambiguity of the word "probability" in the original problem, which might be interpreted as meaning "typicality", "subjective certainty", or "expectedness."

Markus and Zajonc's (1988) results led them to consider that at least part of the conjunction fallacy is due to inability of the subjects to form a proper sample space, and

that the inability to form the correct sample space was in turn caused by a misunderstanding of the target statements.

All of these manipulations indicate a significant misinterpretational component to responses to the Linda problem. What is missing from all of these experiments, however, is an approach that combines manipulations that address different ambiguities in a single problem version as Margolis (1987) has suggested. What is also missing from these studies is any clear-cut evidence that the manipulations which facilitate correct responding do so by creating a different interpretation than that which would exist without the manipulation. That a certain manipulation causes a different pattern of responding is not direct evidence that the different pattern of responding is being mediated by a different problem interpretation.

Four experiments were designed to address each of these two concerns. Experiment 1 was designed to investigate simultaneous manipulations of different aspects of the Linda problem as suggested by Margolis (1987). Experiments 2 and 3 were follow-up experiments to Experiment 1. Experiment 4 was designed to provide direct evidence that one particular facilitating manipulation found to be robust and replicable in Experiments 1 and 3 was accompanied by changes in an interpretation of one of the response options. An overview of these four experiments is provided in the next section.

Overview of Experiments and Their Rationale

Like Margolis and many other experimenters, I agree that subjects are misunderstanding the question posed by the Linda problem and that the main difficulty is that subjects think they are being asked to make some sort of a typicality judgment instead of a judgment of relative frequency. I also agree with Margolis's two semantic ambiguities, but feel that there are also others, as I have already mentioned. Even with clarification of the relative frequency context, there will still be some ambiguity resulting from other parts of the problem.

Let me set forth explicitly my conceptualization of the sources of difficulty in the Linda problem: Level I difficulties consist of the confusion between assessments of $P(H/D)$ and $P(D/H)$, and also between a typicality assessment and an extensional assessment. Level II difficulties consist of the mutual exclusivity problem of the response options and the conditional versus joint probability interpretation of the second option. If a Level I typically interpretation is made, then clarifications at Level II will have little effect, unless they are successful in reversing the Level I interpretation. If a Level I interpretation of $P(H/D)$ or extensionality is made, then the subject might still check the incorrect response because of Level II difficulties. Therefore, there should be an interaction between Level I and Level II manipulations, just as there

should be an interaction between Margolis's scenario and semantic manipulations. Because Level I difficulties are inherent in the problem as constructed, they will be very difficult to correct without changing the problem in some fundamental way. Because the efficacy of changes at Level II rely on reaching the appropriate interpretation at Level I, ambiguities at Level II will also be difficult to resolve, though they should have some effect. Therefore, one might expect only moderate levels of facilitation as a result of any manipulation that does not change the basic structure of the problem.

Margolis (1987) identified three ambiguities in the Linda problem. These were discussed in detail in a previous section, <u>A Survey of Alternative Explanations</u>. Margolis suggested changes in the Linda problem to address each of these three ambiguities. His suggested version of the Linda problem is as follows:

> Linda is 31 years old, bright and outspoken. As an undergraduate she majored in philosophy and was active in the environmental and civil rights movements. A personnel survey showed that of clerical workers in banks (including tellers) fewer than 1% have personality profiles that sound similar to Linda's.
>
> If you stood to win $10 if the statement you choose turns out to be true (whether or not the other statement is also true), which choice is more likely to win you the $10? Circle one:
>
> (a) Linda is a bank teller.
> (b) Linda is a bank teller active in the feminist movement.

The betting scenario was added to cue subjects to an extensional interpretation. The "whether or not" phrase--embedded in the betting scenario--was added to address the mutual exclusivity problem of the response options. The survey information was added to alert subjects to the fact that, in the case of either option, values are quite small. These are the three ambiguities that concerned Margolis and the three changes he added to address them.

However, it should be noted that the description of Linda that Margolis uses is somewhat less strongly stated than that used by Kahneman and Tversky. The betting scenario is also worded differently.

Margolis's suggestions were used as a framework in designing Experiments 1 through 3. In order to make the results of the experiments more interpretable, the standard Linda description utilized by Kahneman and Tversky was used throughout. The Kahneman and Tversky betting scenario was also substituted when used. Because it seemed as if the "whether or not" phrase of Margolis did not address the mutually exclusive "or" problem of the response options as would a phrase added directly to the response option, the phrase "regardless of whether or not she is also a feminist" was added to "Linda is a bank teller" as a manipulation.

Experiment 1 was designed to investigate the relationship between three changes to the Linda problem, each of which addressed one of the three ambiguities

identified by Margolis (1987). A main effect was found for the "regardless phrase" along with its interaction with each of the two other manipulations--the betting scenario and survey information.

It was considered that the main effect of the "regardless" phrase might be due to two different reasons. One , that the phrase acted to disambiguate the response option. The other, that the additional length of the phrase served as an attentional cue. In Experiment 2, length of both response options was systematically varied and yielded null results, both for changes in length and for the "regardless" phrase that worked in Experiment 1. In order to attempt to replicate the results of the "regardless" phrase found in Experiment 1 and to investigate whether a slight inadvertent wording change in Experiment 2--using "likely" instead of "probable"--had caused the "regardless" phrase to be ineffectual, Experiment 3 was designed. Experiment 3 used the "regardless" phrase, the betting scenario, and "likely" versus "regardless" as experimental factors. Experiment 3 replicated the main effects of the "regardless" phrase and gave no indication that "likely" used in place of "probable" made any difference. Experiment 3 did not replicate the interaction of the betting scenario with the "regardless" phrase that was indicated in Experiment 1.

In order to be certain that the "regardless" phrase would replicate again, and also to ascertain whether the facilitating effects of the phrase were due to differences in interpretation of the response options, Experiment 4 was designed. Experiment 4 utilized Euler circles along with the "regardless" phrase as an experimental factor. The results indicated differences in interpretation of the response options as a result of the "regardless" phrase. The next four chapters describe in detail each of the four experiments.

EXPERIMENT 1

Margolis (1987) is the first author to have suggested
that subjects' difficulties with the Linda problem are the
result of three simultaneous ambiguities. If this is the
case, then a problem version that contains manipulations
that address all three ambiguities should result in
significant facilitation. Interactions between the
manipulations could be either additive or interactive. Seen
from the perspective of Level I/Level II ambiguities,
however, there should be an interaction between the
different manipulations. Specifically, if a Level I
ambiguity is not resolved appropriately, then manipulations
at Level II will have no effect.

Experiment 1 was designed to investigate the degree of
facilitation three different wording changes would have on
performance on the Linda problem, and to see whether the
effects that might result would be additive or interactive
in nature.

Three wording changes were independently varied. One
of these--the addition of a betting scenario--was utilized
by Tversky and Kahneman (1983) with a resultant 32%
reduction in the conjunction fallacy. Margolis (1987) also
advocated the use of the betting scenario to cue subjects to

a relative frequency interpretation of probability, rather than probability in the plausibility sense of the word. This distinction between a relative frequency interpretation and a typicality or plausibility interpretation, I consider to occur at Level I, so the betting scenario addresses a Level I ambiguity.

The second wording change is the addition of some survey information which Margolis (1987) says cues subjects not to overlook the small but relevant differences between two categories. The effects of survey information have not been empirically tested before. Survey information, because it emphasizes the sampling space of the two categories, is considered a Level II manipulation.

The third wording change is similar, but not identical to one utilized by Tversky and Kahneman (1983). Tversky and Kahneman added "whether or not she is active in the feminist movement" to the "Linda is a bank teller" response option and found a 25% reduction in the conjunction error. The phrase added to response option "a" in Experiment 1 was "regardless of whether or not she is also active in the feminist movement," which was considered to be a more effective clarification. Both phrases serve the purpose of clarifying the sample space relationship between the two response options and mitigating against the implied mutually exclusive "or."

Margolis also suggested a "whether or not" phrase for the same purpose, but embedded it in the betting scenario. It was considered that this might not be as effective as the phrase attached directly to the response option and so was not used. The "regardless" phrase, because it was an attempt to clarify the sample space of the response options, was considered a Level II manipulation.

It was predicted that the problem version having all three manipulations would show the greatest degree of facilitation. Margolis makes no claim as to whether the manipulations would show additive or interactive effects, but under a Level I/Level II perspective, it was predicted that when a Level I manipulation was present, cuing a relative frequency interpretation, all Level II manipulations would be effective. When the Level I manipulation was not present, it was predicted that Level II manipulations would have little effect.

Method

Subjects. Two hundred introductory psychology students participated in return for partial satisfaction of the course's research requirement. Subjects were enlisted by means of sign-up sheets posted in the psychology department lobby.

Materials and design. All problem versions offered the same description of Linda, which read as follows:

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

Each version also offered two response options. Option "a" always consisted of "Linda is a bank teller", with or without an additional phrase, to be described below, and option "b" always consisted solely of "Linda is a bank teller and is active in the feminist movement".

The design was a three-factor design. Each factor had two levels consisting of the absence or presence of a specific wording change.

The change in wording for the Regardless factor was the addition of a phrase intended to clarify the appropriate category boundaries of the "Linda is a bank teller" option, or response option "a". With the "regardless" phrase added, the complete response option read as follows:

a) Linda is a bank teller, regardless of whether or not she is also active in the feminist movement.

The wording change for the Betting factor was the addition of a betting scenario which was previously utilized by Tversky and Kahneman (1983). The purpose of the betting scenario was to attempt to discourage a "plausibility" interpretation of the word "probable" and instead cue a statistical interpretation of the problem. The betting scenario read as follows:

> If you could win $10 by betting on an event, which of the following would you choose to bet on? (check one)

These instructions were immediately followed by the two response options. For the 100 subjects who received versions of the problem in which the betting scenario was absent, the instructions read as follows:

> Which of the following is more probable? (check one)

The wording change for the Survey factor was the addition of some survey information, taken verbatim from Margolis's (1987) suggested version, which advises subjects that small differences between groups are not to be treated as negligible. The survey information, when present, was inserted between the description of Linda and the instructions and read as follows:

> A personnel survey showed that of clerical workers in banks (including tellers) fewer than 1% have personality profiles that sound similar to Linda's.

The eight versions of the Linda problem which resulted from all possible combinations of the presence and absence of these three wording changes are presented in Appendix A.

Procedure. Subjects were administered the problems in groups of from 5 to 15 in a small classroom. The eight versions were distributed across subjects such that one subject received only one version of the problem, and so that each of the eight cells gradually and uniformly filled to 25.

The data were analyzed using a three-factor ANOVA.
Probability levels were set at .05 for main effects. Due to
the reduction in power resulting from fewer subjects in the
comparison groups as groups were subdivided, probability
values for interaction effects were set at .10.

Results

The proportions of incorrect responses for each of the
eight versions of the Linda problem are given in Table 1.

TABLE 1

PROPORTIONS OF INCORRECT RESPONSES IN EXPERIMENT 1

	Regardless	
Survey	Absent	Present
Absent		
Betting absent	88	40
Betting present	84	68
Present		
Betting absent	68	52
Betting present	68	64

The only significant main effect was for the Regardless factor, $F(1,192) = 10.50$, $p < .05$. There were 21% fewer conjunction errors when the "regardless" phrase was present than when it was absent. However, this factor was involved in two significant interactions, Regardless X Survey and Regardless X Betting, $F(1,192) = 2.88$, $p < .10$, in both cases.

Multiple comparison follow-ups of the Regardless X Survey interaction indicate that when survey information was absent, the addition of the "regardless" phrase facilitated a significant 32% reduction in error, $t(192) = 3.73$, $p < .10$. However, when survey information was present, there was no significant difference in the percentages of incorrect responses between the conditions of "regardless" present and "regardless" absent.

Similar multiple comparison follow-ups were performed on the groups in the Regardless X Betting interaction. When the betting scenario was absent, the presence of the "regardless" phrase significantly facilitated correct responding by 32%, $t(192) = 3.49$, $p < .10$. However, when the betting scenario was present, the presence or absence of the "regardless" phrase made no significant difference in the proportion of correct responses.

Discussion

It was predicted that the problem version having all three wording changes present would result in the largest degree of facilitation. This was not the case, and such results present difficulties for Margolis's theory.

There was an interactive effect among the three wording changes instead of an additive effect. The "regardless" phrase manifested a strong facilitative effect, which replicates the results of Tversky and Kahneman (1983), who reported a 25% reduction in error when adding a similar phrase. However, the effect did not operate under all wording conditions. For example, when survey information was present, it made no significant difference if the "regardless" phrase was present or not. Likewise, when the "regardless" phrase was present, it mattered little if survey information was present or not. There was, however, a nonsignificant difference of 18% in the predicted direction of facilitation by survey information when "regardless" was absent. The tentative conclusion is drawn that survey information and "regardless" both facilitate correct responding to some degree, but that "regardless" is much more effective at doing so. When both are present, their effects are not additive and therefore no further facilitation is seen.

This can be understood if both manipulations are seen as operating at Level II and both are involved in clarifying

the sample space of the response option, though both may be operating in slightly different ways. The sample space is more likely to be clarified by the "regardless" phrase than survey information, but together they work no better than either alone.

The interpretation of the Regardless X Betting interaction is slightly different. When the betting scenario was absent, "regardless" had a strong facilitative effect. However, when both the betting scenario and "regardless" were both present, the observed proportions suggest that the betting scenario detracted from the effects of "regardless." If, as already mentioned, the effect of survey information is somewhat facilitative in the absence of the "regardless" phrase, then the Survey X Betting interaction should show that the betting scenario inhibits the facilitation of survey information as it does for "regardless". Although the Survey X Betting interaction was not a significant one, the observed proportions suggest that this was the case. When survey information was present, there was slightly higher incorrect responding with the betting scenario present than with it absent.

Such findings are difficult to reconcile with the predictions of the Level I/Level II perspective. If operating at Level I, the presence of Betting should have enhanced the effects of Survey and Regardless. It seems instead that its presence detracted. The tentative

conclusion is that Betting does not contribute to appropriately clarifying a Level I ambiguity.

The lack of main effects of the betting scenario in this experiment is at odds with the facilitative results of the betting scenario reported by Tversky and Kahneman (1983). It should be noted, however, that there is, both in this experiment, and in the Tversky and Kahneman (1983) problem, a confound involved with the betting scenario. Adding the betting scenario results in the removal of the instructions to choose the most probable option. The presence and absence of these instructions and the presence and absence of the betting scenario should have been manipulated independently of one another. This does not, however, explain why this experiment did not replicate the betting scenario results of Tversky and Kahneman (1983).

It is possible that there is an alternative explanation to the facilitative effects of the "regardless" phrase of Experiment 1 other than that the phrase was operates to clarify an ambiguous interpretation of option "a". The other explanation is that the addition of the phrase lengthens option "a" beyond that of option "b" and that it is this additional length which determines option choice. This interpretation would also explain why subjects choose option "b" when the "regardless" phrase is absent from option "a", because then option "b" would be the longer

option. In order to test this hypothesis, Experiment 2 was conducted.

EXPERIMENT 2

The results of Experiment 1 indicated that the "regardless" phrase played a role in facilitating correct responses to the Linda problem. It was assumed that any such role the phrase played would be the result of diminishing the role of the mutually exclusive "or" by explicitly indicating the inclusive nature of option "a." However, there is an alternative explanation for why the "regardless" phrase was effective. It is possible that length is a factor that works to cue the attention of the subject. The longer phrase might seem more important or appear to contain more information. Length could work as an attentional pointer which causes subjects to choose option "a" when the "regardless" phrase is present for reasons other than that the phrase is clarifying sample space.

Evans's (1988) theory of reasoning posits an initial stage during which aspects of a problem are selected to be subsequently manipulated. This selection takes place at an unconscious level. Length could work as a factor that increases the probability of an item's being selectively attended to. Option "a" with the "regardless" phrase could be being chosen more often merely because it is more salient.

In order to determine whether this was the case, Experiment 2 was conducted. A lengthening "regardless" phrase was independently added to options "a" and "b." It was predicted that if length was the deciding factor in subjects' choices, that when a "regardless" phrase was added to option "a," percentages of subjects choosing option "a" would increase. When a "regardless" phrase was added to both option "a" and "b," then "b" would be the longer option and choices of option "b" would increase. When a "regardless" phrase was added to "b" alone, the percentages of subjects choosing "b" should be very high. If, on the other hand, the "regardless" phrase was effective because it clarified interpretations of option "a," it would cause increased selection of option "a" regardless of whether or not a "regardless" phrase was also attached to option "b."

Method

Subjects. Subjects were 84 introductory psychology students who were enlisted by means of sign-up sheets. Participation partially satisfied the course's research requirement.

Materials and design. The design was a two-factor between-subjects design. The levels of each factor consisted of the absence or presence of a lengthening phrase. For option "a", the phrase was the "regardless"

phrase used in Experiment 1. For option "b", the phrase was as follows:

> regardless of what other activities she also participates in

The description of Linda used was the same as that used in Experiment 1, and the instructions read as follows:

> Which is more likely? (check one):

The four problem versions used in Experiment 2 are presented in Appendix B.

Procedure. Subjects were run in small groups of from 5 to 15 in a small classroom. The data were analyzed using a two-factor ANOVA. Probability levels were set at .05 for main effects and .10 for interaction effects.

Results

There were no significant main or interaction effects. Proportions of incorrect responses for the four cells are given in Table 2.

Discussion

The results of Experiment 2 indicate that length was not a factor in selection of an option. However, the facilitative effects of the "regardless" phrase as found in Experiment 1 were not replicated either.

It was noted after the experiment was conducted that "likely" had been used in the instructions in place of the

"probable" that was used in Experiment 1. The reason for this substitution was that while "probable" was used by Tversky and Kahneman (1982, 1983), "likely" was used by Margolis (1987). An oversight on my part caused me to substitute "likely" for "probable" in all four problem versions of Experiment 2.

TABLE 2

PROPORTIONS OF INCORRECT RESPONSES IN EXPERIMENT 2

Regardless in "b"	Regardless in "a"	
	Absent	Present
Absent	81	76
Present	67	71

It was considered whether the "regardless" phrase could possibly interact with the word "likely" in the instructions of Experiment 2 in a different way than with the word "probable," which was used in Experiment 1. To follow up on this possibility, an additional 21 subjects were tested with a problem version which contained "probable" in the instructions, and the "regardless" phrase added to option

"a." There was 57% incorrect responding to this version, a value not significantly different from the version that used "likely" (76%), $t(40) = 1.33$, $p > .05$, but in the direction of the suspected interaction and similar enough to the 21% main effect reduction seen in Experiment 1 to warrant further inquiry. In order to resolve the possibility of there being different effects of the "regardless" phrase when used with "likely" and "probable," to attempt to replicate the main effects of "regardless" seen in Experiment 1, and to further examine the effects of the betting scenario used in Experiment 1 in an unconfounded design, Experiment 3 was conducted.

EXPERIMENT 3

Experiment 3 had three experimental factors: (a) the "regardless" phrase in option "a," (b) the betting scenario, and (c) use of either "likely" or "probable" in the instructions.

The design of the experiment was such that the addition of the betting scenario was not confounded with the removal of the instructions to choose the most probable option, as it was in Experiment 1.

It was predicted that Regardless would facilitate and would also interact with Betting, replicating the results of Experiment 1. It was also predicted that Regardless would interact with Likely/Probable such that Regardless would facilitate with the presence of "probable" but would be ineffective with the presence of "likely." An admittedly post hoc explanation for this expected Regardless X Likely/Regardless interaction was that "probable" has connotations of a slightly more statistical nature, leaving more room for an influence by Regardless. "Likely" seems more synonymous with "plausible" or "believable" and more likely to cue a "plausibility" Level I scenario. Given the Level I/Level II perspective, the Level II manipulation of

Regardless would be relatively ineffectual with that Level I scenario.

Method

Subjects. One hundred and sixty introductory psychology students participated voluntarily. The students were enlisted by means of sign-up sheets placed in the lobby of the psychology building. Participants were given credit toward the completion of the course research requirement.

Materials and design. The design was a three-factor between-subjects design similar to that utilized in Experiment 1. The Regardless factor consisted of the same two levels of the presence or absence of the "regardless" phrase in option "a" and the Betting factor of the presence or absence of the same betting scenario as was used in Experiment 1. The description of Linda was the same as that used in Experiments 1 and 2. The Likely/Probable factor had two levels: either the use of the word "likely" in the instructions, or the use of the word "probable". When the betting scenario was absent, the instructions read as follows:

> Which of the following is more probable [or likely]? Check one:

When the betting scenario was present, the instructions read as follows:

>   If you could win $10 by betting correctly,
> which of the following would you bet is more
> probable [or likely]? Check one:

In this way there was no confounding between the addition of the betting scenario and the removal of the words "likely" or "probable" as there was in Experiment 1. The eight versions of the Linda problem that resulted from all possible combinations of these three manipulations are collected in Appendix C.

Procedure. Subjects were run in small groups of from 5 to 15 in a small classroom. The results were analyzed using a three-factor ANOVA. Probability levels were set at .05 for main effects and .10 for interaction effects.

Results

The proportions of incorrect responses for each of the eight versions of the problem are given in Table 3.

There was a main effect of the Regardless factor, $F(1,152) = 8.81$, $p < .05$, with a 19% reduction in error in those cells where the "regardless" phrase was present compared to those cells in which it was not. There were no significant main effects for the Betting factor or for the Likely/Probable factor, and there were no significant interaction effects.

TABLE 3

PROPORTIONS OF INCORRECT RESPONSES IN EXPERIMENT 3

Probable/Likely	Regardless	
	Absent	Present
Probable present		
Betting absent	95	65
Betting present	90	65
Likely present		
Betting absent	90	80
Betting present	80	70

Discussion

The effects of "regardless" seen in Experiment 1 were replicated here in Experiment 3. The degree of effect was very similar, with 19% here, compared to the 21% seen in Experiment 1.

The betting scenario once again defied predictions and was ineffectual in facilitating correct responding, this time in an unconfounded design. Neither did Betting interact with Regardless as was seen in Experiment 1. However, due to the confounds of Experiment 1, it is

difficult to know whether the Regardless X Betting interaction seen in that experiment was due to the effects of the addition of the betting scenario, or to the effects of the removal of the instructions to choose the most probable option. The results of Experiment 3 indicate that in an unconfounded design, there is no interaction between Betting and Regardless. Lack of main effects and lack of interaction effects call into question the efficacy of the betting scenario as a manipulation capable of bringing about a shift in Level I interpretation. Tversky and Kahneman's (1983) results are not replicated and Margolis's (1987) choice of the betting scenario as a manipulative factor are called into question.

No evidence was found in the results of Experiment 3 for any difference between "likely" and "probable" in the instructions, either in main effects or interaction effects. The Likely/Probable factor is therefore also ruled out as an effective manipulation at Level I.

At this point the only effective and replicated manipulation seemed to be the "regardless" phrase. To further investigate the role of Regardless in facilitating correct responding to the Linda problem, Experiment 4 was designed. A way was sought that would reveal whether subjects who chose option "a" when "regardless" was present were interpreting that option any differently than those subjects for whom "regardless" was not present. It was

considered that the best way to ascertain this was to have subjects select a visual representation of the category membership relationships indicated by the response options. Euler circles are a convenient way to represent category membership. Therefore in Experiment 4 an additional task was assigned to the subject: The selection among an array of Euler circle pairs of the pair that best represented options "a" and "b" in the Linda problem. It was assumed that these choices would reflect interpretational differences. In order to ascertain whether the Regardless factor would affect the choice of differing visual representations for option "a," Experiment 4 was conducted.

EXPERIMENT 4

To further investigate the role of the "regardless"
phrase in facilitating correct responding to the Linda
problem, Experiment 4 was designed. In Experiment 4 an
additional task was assigned to the subject. Seven
overlapping pairs of Euler circles were added to the Linda
problem, a circle in each pair representing the category of
bank teller, the other, the category of feminist. Subjects
were asked to choose among the particular shadings. All
possible shading combinations were represented. In other
words, the particular shading of one circle pair would
represent the category "all bank tellers", another, the
category "all feminists except those who are also bank
tellers," etc. The additional task assigned the subject was
to identify those two circle pairs that represented the
categories indicated by options "a" and "b." This
arrangement allowed a test of whether the facilitating
effects of the "regardless" phrase were associated with
differences in interpretation of option "a." Specifically,
if "Linda is a bank teller" is being interpreted as "Linda
is a bank teller and not a feminist," such an interpretation
should result in the choice of the circle pair which is
shaded in such a way as to represent "bank tellers who are

not also feminists" or a half-moon shape. If the addition
of the "regardless" phrase acts to clarify this ambiguity,
then the augmented option "a" that reads "Linda is a bank
teller, regardless of whether or not she is also active in
the feminist movement" should be reflected in the choice of
the Euler circle pair whose shading represents all bank
tellers, or a completely shaded circle.

It was predicted that the presence of the "regardless"
phrase would result in a higher percentage of subjects
choosing option "a." It was further predicted that Euler
circle choices would reflect differences in interpretation
due to the presence of the "regardless" phrase.
Specifically, it was predicted that under both Regardless
conditions, subjects choosing option "b" as the correct
answer would check the half-moon circle for option "a,"
indicating they had interpreted "Linda is a bank teller" as
"Linda is a bank teller and not a feminist." Subjects
choosing option "a" as the correct answer would check the
fully shaded circle for option "a," indicating that they had
understood the inclusive nature of "Linda is a bank teller."
Furthermore, it was predicted that the increase in the
choice of option "a" caused by the "regardless" phrase,
would be accompanied by an identical increase in the choice
of the fully shaded bank teller circle to represent option
"a." It was predicted that there would be no difference

between the two groups in their selection of the Euler
circle patterns representing option "b."

Method

Subjects.   Twenty introductory psychology students were
enlisted by means of sign-up sheets, and participated in
return for partial credit toward the course's research
requirement.

Materials and design.   The design was a one-factor
between-subjects design.   The "regardless" phrase was either
present or absent in option "a."   At the bottom of the same
page on which the Linda problem was printed were these
additional instructions:

> The circles on the left represent all bank
> tellers.   The circles on the right represent all
> feminists.   The area where two circles overlap
> represents all those who are both bank tellers and
> feminists.   Place the letters "a" and "b"
> corresponding to the two statements above next to
> those two diagrams which you think capture
> visually the meanings of the statements.

Following these instructions were the seven pairs of
differently shaded Euler circles, each preceded by a blank
for responses.   The order of the shading was presented in
different random sequences, counterbalanced across subjects.
Representative examples of the two problem versions with
Euler circle pairs are presented in Appendix D.

Procedure.   Subjects were run in two small groups in a
small classroom.   A brief explanation of overlapping Euler

circles involving an example of people with blond hair and blue eyes preceded distribution of the problems. Data were analyzed in one-tailed t-tests, with probability values set at .05.

Results

Of the ten subjects who received the problem without the "regardless" phrase, 80% chose option "b." Of the ten subjects who received the problem with the "regardless" phrase, 40% chose option "b," a significant 40% reduction in error, $t(18) = 2.00$, $p < .05$, which replicates the "regardless" results of Experiments 1 and 3.

In the no "regardless" group, 10% chose the fully shaded circle which represented "all bank tellers," 70% chose the shaded half moon which represented "bank tellers who are not feminists," and 20% chose other shaded representations.

In the "regardless" group, 60% chose the fully shaded circle which represented "all bank tellers," 20% chose the shaded half moon which represented "bank tellers who are not feminists," and again, 20% chose other shaded representations.

The 50% difference between the "regardless" and no "regardless" groups in choosing the fully shaded "all bank tellers" circle was significant, $t(18) = 2.75$, $p < .05$.

Discussion

Experiment 4 replicates the effect of Regardless as shown in Experiments 1 and 3. It appears that the "regardless" phrase's effects are a robust phenomenon.

The significant difference between Euler circle choices indicates that the "regardless" phrase is instrumental in driving an appropriate interpretation of option "a." However, it is not accurate to say that those who chose option "a" all picked the fully shaded circle, and those who chose option "b" all picked the half-moon shaded circle. Two of the four people in the "regardless" group who chose option "b" nonetheless picked the fully shaded circle to represent option "a," and one of the six in that group who correctly chose option "a" nonetheless picked the partially shaded circle for option "a." Likewise, in the no "regardless" group, the two people who correctly chose "a" nonetheless picked the partially shaded circle, and one person who chose "b" picked the fully shaded circle. It appears that although "regardless" facilitates option "a" as the correct choice, and also facilitates the choice of the fully shaded circle as representing "Linda is a bank teller", the two effects are not identical or perfectly correlated.

GENERAL DISCUSSION

In an earlier section of this dissertation, the historical and philosophical overview criticized the Kahneman and Tversky approach to reasoning research as being overly restrictive and ignoring variables of content and context. Their approach is also a highly pejorative one when comparing the reasoning competences of the layperson to the workings of formal statistical principles. Such an approach was shown to have historical precedents, but was also shown to have a historical counterpoint. There is currently a renewal in the approach to consider the role of content in the reasoning process, and the background context in which it occurs, as well as the goals of the reasoner (e.g., Baron, 1988; Cosmides, 1990; Evans, 1989; Margolis, 1987). There is a shift away from the statistical metaphor to the perceptual metaphor.

Not only has there been a redressing of balances within the larger context of general approach, but on a more microscopic scale much has been shown to be amiss about the details of the Kahneman and Tversky program. It is at this level that this dissertation has attempted to contribute some empirical evidence.

It has been argued that with the Linda problem as it is constructed, there is an overwhelming tendency to see the task in terms of matching a set of characteristics to a prototype. The pragmatic invitation to make this interpretation is built into the very structure of the problem and the information offered. Though I have called this a Level I ambiguity, there is little hesitation on the part of the subject in seeing the problem this way. It has been the argument of this dissertation that even when subjects can be brought to appropriately resolve the Level I ambiguity of the problem and make an appropriate interpretation of the problem in terms of overlapping category sets, that Level II ambiguities can still detract from their performance.

Margolis (1987) has argued that multiple ambiguities beset the Linda problem and offered manipulations to address those ambiguities. How do the experimental results of this dissertation contribute to any discussion concerning the three viewpoints of Tversky and Kahneman, Margolis, and the Level I/Level II perspective?

A summary of the experimental results are as follows: (a) there is no evidence that a betting scenario plays any direct facilitating role; (b) there are indications that survey information acts as a somewhat successful facilitation; (c) there is no evidence that "likely" operates any differently than "probable"; and (d) there is

evidence that the "regardless" phrase is a moderate facilitator and that its effects are not due to option length but to a shift in the sample space interpretation of the response options by the subject.

On the whole, no manipulation resulted in a very large reduction in conjunction error: The Linda problem is robust in its resistance to facilitating manipulations. However, it has already been suggested that the very structure of the problem will make it resistant in this way.

Changing the task structure of conjunction problems can have impressive effects. Tversky and Kahneman (1983) developed a health-survey conjunction problem which asked subjects for two estimates: the percentages of men who have had one or more heart attacks, and the percentages of men who are over 55 and have had one or more heart attacks. The pragmatic structure of this question is not as overwhelming as that of the Linda problem, so conjunction effects were not as high, but still, 65% of respondents assigned a higher value to the second estimate. When the task was changed to one of estimating how many out of 100 men fell into the two categories, the conjunction error fell to 25%. To my mind, this change in task structure qualifies as a Level I manipulation or as a scenario manipulation in Margolis's terms: It tends to shift subjects toward a relative frequency interpretation. Tversky and Kahneman (1983) then- -in the only case where they combined two different

manipulations--added a third estimate to the "out of 100 men" health-survey problem. This estimate was of the number of men over 55. These three estimates now present the joint event along with both of its constituents and should make sample space confusions less likely. This manipulation qualifies as a Level II manipulation and given the Level I manipulation of the new task instructions should prove to be effective. In fact, the conjunction error fell to 11% with these two manipulations, one of the lowest values ever reported for a conjunction problem.

Of course, the interpretation of these results within the Level I/Level II perspective is my own. Tversky and Kahneman (1983) do not have any comprehensive framework within which they can interpret such findings and instead focus on the prevalence of the representativeness heuristic in the remaining 11% of responses.

Fiedler (1988) revised the Linda problem so that subjects estimated to how many out of 100 such descriptions would the target items apply. He reports that the conjunction effect fell to 22%. It would be interesting to combine this Level I manipulation for the Linda problem with the Level II manipulation of the "regardless" phrase to see if the error would be reduced any further.

Morier and Borgida's (1984) findings that the conjunction error depended on the kind and number of response options and whether probability estimates or

probability rankings were asked for led them to label the conjunction fallacy a task-specific phenomenon. The perceptual metaphor predicts task-specificity of such an effect.

These studies all offer evidence that changes in task structure can serve as a Level I manipulation, at the same time that the results of this dissertation call into question the efficacy of the betting scenario as a Level I manipulation. Other than the single report (Tversky & Kahneman, 1983) of an effect of betting scenario, no other study utilizing the betting scenario has appeared until recently (Wolford, Taylor, & Beck, 1990). Wolford et al. compared a version of the Linda problem with a betting scenario to a version without the betting scenario and found no significant difference in responses between the two.

Experiment 3 of the present study found no effects of an unconfounded betting scenario and Experiment 1 found no effects of Betting. The marginal interaction effects seen in Experiment 1 may be spurious or they may have resulted from the confounding of the addition of the betting scenario with the removal of the word "probable" in the instructions.

Further investigations could address this issue, but, in any case, the betting scenario in Experiment 1 seemed to detract from the facilitative effects of Regardless, not what one would expect if the betting scenario was operating at Level I.

Margolis (1987) chose the betting scenario as the manipulation to address the frequency/plausibility ambiguity in the Linda problem. The empirical results call his choice into question. However, Margolis (personal communication, 1989) has expressed the belief that sufficient differences exist between his betting scenario and the one utilized in this study. He feels his version would nonetheless provide facilitation. Only further empirical work would establish his claim.

Margolis's (1987) second suggested manipulation was the addition of survey information. This short series of experiments was unable to fully explore the implications of Experiment 1, which indicated some contribution to correct responding by survey information. Recall that in that experiment, in the absence of "regardless," the presence of survey information helped correct responding by 18% compared to its absence. As an additional note, the Bill problem, a conjunction problem similar to the Linda problem, was run in second and third position behind the Linda problem in Experiment 3 as a pilot study. The three factors of the Bill problem were Survey, Betting, and Probable/Likely. The results should be interpreted cautiously, but there was a main effect for survey information, with a 24% reduction in error compared to its absence. How survey information achieves its facilitating effects is a topic for further study. A perusal of the cell percentages in Experiment 1

where both Regardless and Survey were factors indicates that the effects of "regardless" and survey information are not strictly redundant. Survey information seems to be doing the same thing as "regardless" but in a slightly different way. Perhaps a study with Euler circles as in Experiment 4, but with Survey as a factor in place of Regardless would be fruitful. Within the Level I/Level II framework, survey information would be considered as a Level II manipulation.

No conclusive evidence was found in this study for any role of "likely" versus "probable" in task instructions as a Level I manipulation, as was somewhat suggested by the results of Experiment 2. No effects of the Likely/Probable factor were found in Experiment 3. In addition, a recent study (Macdonald & Gilhooly, 1990) had one group of subjects rank the eight statements in the eight-statement version of the Linda problem by probability, and another group rank by believability. There were no effects of this manipulation.

The fourth and final empirical contribution of the present study is evidence that the "regardless" phrase is a moderate facilitator. The Regardless factor was considered a Level II manipulation, but it was seen that it could work alone. It is possible that the "regardless" phrase works only in those cases where subjects have already brought the appropriate Level I set to the problem, or it is also possible that the "regardless" phrase can also work to cue the appropriate Level I interpretation on its own, in

addition to clarifying sample space. In this study, no effective Level I manipulations were found in either Betting or Likely/Probable, but a logical next step is to utilize the "regardless" phrase in a study where a postulated Level I manipulation is effective, as in the out-of-a-hundred estimation version of a conjunction problem studied by Tversky and Kahneman (1983) and Fiedler (1988).

Experiment 4 provides evidence that the "regardless" phrase works because it clarifies category relationships. While Tversky and Kahneman (1982, 1983) say that the appropriate interpretation of the Linda problem is in terms of the conjunction rule, it is really a very restricted application of the conjunction rule which they have in mind. What the Linda problem really is about is category membership and the ability to see one category as being subsumed under another.

A significant part of the poor performance usually seen with the Linda problem can be accounted for by a misinterpretation on the part of the subject to which he is led by the conventions of natural language. To this degree Tversky and Kahneman have exploited the reasonableness of human reasoning. The reduction of the Linda problem from its place in an argument crafted to attack the rationality of human thought to an insipid fragment of verbal trickery has its counterpart in another similar area of human reasoning research, that of research into logical thought.

Inhelder and Piaget (1964) showed children an array of flowers, consisting of more tulips than roses, then asked if there were more flowers or more tulips. Children younger than five answered that there were more tulips, which Inhelder and Piaget concluded to mean that the children were incapable of logically comparing a category to a subcategory. Gardner (1985) discusses how children may merely be making the reasonable interpretation that a comparison between the two kinds of flowers is being asked for. When the question is more appropriately phrased, or when class/subclass comparisons are appropriate, children are able to reason competently about class inclusions.

The parallel with the Linda problem is striking. Subjects are really being asked to make an inference about class inclusion when such an inference is not at all relevant to what they think they are being asked to do. In the case of the Linda problem, however, even when the idea of category membership is communicated to the subject, exactly what the subclasses are can be misconstrued. This, clearly, is the import of Experiment 4. The "regardless" phrase, if it is appropriately incorporated by the subject into the correct Level I interpretation, helps subjects to see what classes and subclasses they are being asked to compare. The "regardless" phrase allows them to form the appropriate sample space. It is quite interesting, though, that the appropriate interpretation of the "Linda is a bank

teller" category as including those who may also be feminists does not correlate perfectly with the choice of that option as the most probable one. It will take a larger sample size to see how common the phenomenon is, but Experiment 4 at least indicates that subjects can achieve the correct interpretation of Linda as bank teller and possibly feminist for option "a" and still choose option "b" as being more probable. Is it possible that they are able to correctly assess the sample space with the additional "regardless" phrase and still fall prey to the pragmatic pull of the problem towards a prototype matching task? Perhaps the addition of the Euler circles merely splits the problem into two tasks, for one of which the "regardless" phrase creates the right sample space, but the other of which is still driven by the basic overall mood of the problem.

Experiment 4 also indicates that a subject can assess "Linda is a bank teller, regardless of whether or not she is also a feminist" as a category that excludes feminists and still choose that option as more probable. Does this mean that the "regardless" phrase is working at some level other than in the resolution of an appropriate sample space?

Although Experiment 4 indicates that the "regardless" phrase plays a definite role in both correct sample space interpretation of "Linda is a bank teller" and also in seeing that that option is the more likely one, it is

important that this finding be replicated. Perhaps further research can also clarify why correct sample space interpretation and correct responding as to the most likely option are not more closely correlated.

The efficacy of the "regardless" phrase in causing a moderate reduction in the conjunction fallacy and the Euler circle representations that subjects choose when "regardless" is not present, indicates that subjects do take a noninclusive interpretation of the two response options. A recent study (Agnoli & Krantz, 1989) that became available during the course of the present study is relevant to this discussion. Agnoli and Krantz (1989) hypothesized that people lack a useful design for mapping extensional principles onto conjunction problems. They state that, in everyday life, one does not usually find inclusive relationships among alternatives, and therefore, people do not have the problem solving design to search for inclusions. In order to train people in the search for inclusion relations, Agnoli and Krantz utilized a training module that portrayed inclusion relations by means of Euler circles. Here, Euler circles were used in training, rather than as a measure of interpretation, as they were in Experiment 4 of this dissertation. Use of the training module resulted in about a 30% reduction in conjunction errors on the eight-statement version of the Linda problem. Agnoli and Krantz (1989) concluded that the training module

"affects the probability of errors by changing the competitive balance between extensional and intentional strategies, rather than by changing how each kind of strategy operates once it is engaged" (p. 536).

Agnoli and Krantz also found that changing the "X is a B" statement to "X is a B and may or may not be an A" resulted in a small reduction in conjunction error in seven out of eight eight-statement conjunction problems. Curiously, the interaction between training and the "may or may not be" phrase in these problems was negative, with the change in wording reducing the magnitude of the training effects. Nevertheless, Agnoli and Krantz have shown that training subjects in the inclusion properties of Euler circles had significant effects. Such training could have only made the appropriate Level I interpretation more likely.

In addition to the above study, two other studies relevant to this dissertation have come recently into print. Both are important to the arguments of this dissertation because they explicitly explore the role of context in the Linda problem.

Wolford, Taylor, & Beck (1990) provide evidence that the degree of conjunction fallacy depends on the context of the conjunction problem. Specifically, it is important whether it is perceived that the event had already occurred or has yet to occur. The authors suggest that it is only in

situations where the task is to predict an unknown outcome that conjunctive events are being dealt with and the conjunction rule applies. In situations where the outcome has already occurred and the task is to discover the correct outcome, what is being dealt with is conjunctive evidence and Bayes's Theorem is more appropriately the normative model to employ. Changing decisions about Linda to the probability of what she will be ten years in future reduced the conjunction error by 31%. Subjects also rated problems as to whether the outcome was known or would not be known until the future. Wilford et al. concluded that subjects are able to distinguish between the two models and show enough sensitivity to context to be able to apply those models differentially to the types of situations where they are appropriate.

A scenario that places an outcome in the future is therefore a possible candidate for a Level I manipulation. An experiment which investigates the interaction of a future scenario with the Level II manipulation of the "regardless" phrase would prove interesting.

Macdonald and Gilhooly (1990) were also concerned with the effects of context and the influences of normal conversational assumptions on the Linda problem. The authors consider whether asking the question "Is X a Y?" doesn't provide evidence to the subject that X may indeed be a Y. Macdonald and Gilhooly conclude from their results

that this is true: In an eight-statement version of the Linda problem, subjects ranked the probability of the constituent "Linda is a bank teller" higher when the conjunction was present than when it was absent.

Macdonald and Gilhooly also investigated the effects of transposing the Linda problem into the future. In addition they came close to performing the experiment suggested above by adding a "may or may not be active in the feminist movement" phrase to option "a" in the two-statement version of the Linda problem. Instead of designing the experiment to look for interaction effects, however, they used only three conditions: (a) the original Linda problem, (b) Linda in the future, and (c) Linda in the future with the "may or may not be " phrase. Conjunction effects were 75%, 53%, and 21%, respectively, indicating effects of both the future scenario and the "may or may not" phrase.

Macdonald and Gilhooly also discuss the phenomenon of new conceptual combinations (i.e., pet fish, feminist bank teller) within the general inductive framework of Holland, Holyoak, Nisbett, and Thagard (1986).

These studies lend credence to the argument that the perceptual metaphor is shaping current reasoning research by inviting investigators to consider the interpretational components of reasoning tasks. The explanations of Kahneman and Tversky do not provide any comprehensive theory of cognition that can incorporate the findings which result

from the interpretational approach. Margolis (1987) appears
to be correct in his assessment of the Linda problem as
featuring a collusion of ambiguities.

Also with such studies the Linda problem is placed
within the context of the more comprehensive theories
engendered by the perceptual metaphor. The use of the Linda
problem as an example of the representativeness heuristic is
called into question, and a program of future research is
suggested.

MATERIALS FOR EXPERIMENT 1

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

A personnel survey showed that of clerical workers in banks (including tellers) fewer than 1% have personality profiles that sound similar to Linda's.

If you could win $10 by betting on an event, which of the following would you choose to bet on? (check one)

a) Linda is a bank teller

b) Linda is a bank teller and is active in the feminist movement

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

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A personnel survey showed that of clerical workers in banks (including tellers) fewer than 1% have personality profiles that sound similar to Linda's.

Which of the following is more probable? (check one)

a) Linda is a bank teller

b) Linda is a bank teller and is active in the feminist movement

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

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Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

Which of the following is more probable? (check one)

a) Linda is a bank teller, regardless of whether or not she is also active in the feminist movement

b) Linda is a bank teller and is active in the feminist movement

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

A personnel survey showed that of clerical workers in banks (including tellers) fewer than 1% have personality profiles that sound similar to Linda's.

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A personnel survey showed that of clerical workers in banks (including tellers) fewer than 1% have personality profiles that sound similar to Linda's.

Which of the following is more probable? (check one)

a) Linda is a bank teller, regardless of whether or not she is also active in the feminist movement

b) Linda is a bank teller and is active in the feminist movement

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

Which is more likely? (check one)

a) Linda is a bank teller, regardless of whether or not she is also active in the feminist movement

b) Linda is a bank teller and is active in the feminist movement, regardless of what other activities she also participates in

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

Which is more likely? (check one)

a)   Linda is a bank teller

b)   Linda is a bank teller and is active in the feminist movement, regardless of what other activities she also participates in

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

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Which is more likely? (check one)

a)   Linda is a bank teller

b)   Linda is a bank teller and is active in the feminist movement

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Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

Which of the following is more likely? (check one)

a)   Linda is a bank teller

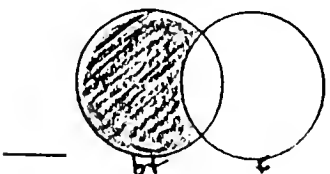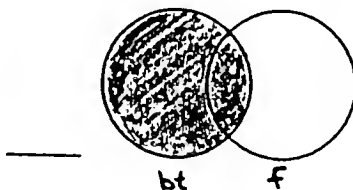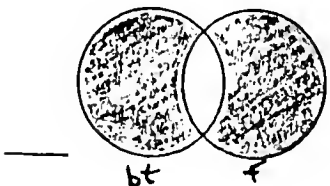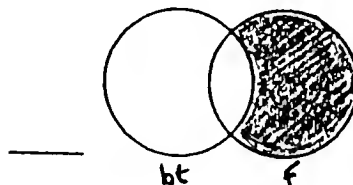b)   Linda is a bank teller and is active in the feminist movement

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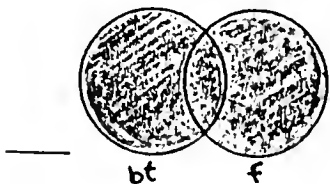
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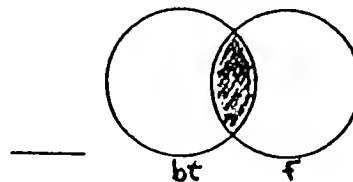
b) Linda is a bank teller and is active in the feminist movement
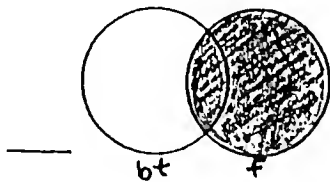
Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

If you could win $10 by betting correctly, which of the following would you bet is more probable? (check one)

a) Linda is a bank teller, regardless of whether or not she is also active in the feminist movement

b) Linda is a bank teller and is active in the feminist movement

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

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If you could win $10 by betting correctly, which of the following would you bet is more likely? (check one)

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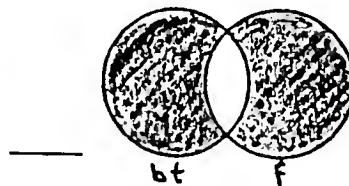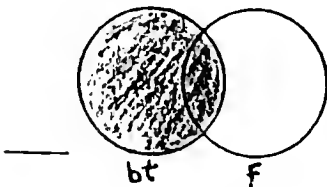b)   Linda is a bank teller and is active in the feminist movement

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

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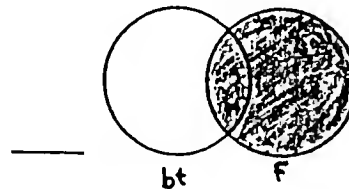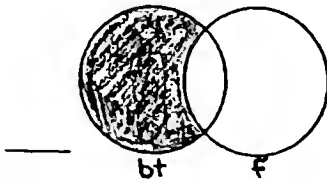APPENDIX D
MATERIALS FOR EXPERIMENT 4

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

Part I: Which of the following is more probable? Check one.

__ a) Linda is a bank teller

__ b) Linda is a bank teller and is active in the feminist movement

Part II: The circle on the left of each pair represents all bank tellers. The circle on the right of each pair represents all feminists. Where the two overlap represents all those who are both bank tellers and feminists. Place the letters "a" and "b" from Part I next to those two diagrams which you think best capture visually the meanings of those statements.

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.

Part I: Which of the following is more probable? Check one.

___ a) Linda is a bank teller, regardless of whether or not she is also active in the feminist movement

___ b) Linda is a bank teller and is active in the feminist movement

Part II: The circle on the left of each pair represents all bank tellers. The circle on the right of each pair represents all feminists. Where the two overlap represents all those who are both bank tellers and feminists. Place the letters "a" and "b" from Part I next to those two diagrams which you think best capture visually the meanings of those statements.

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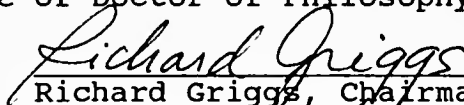
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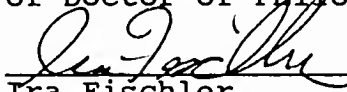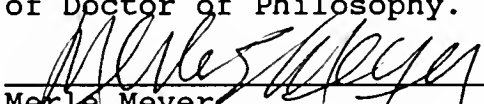
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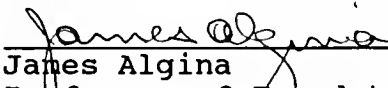
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